

## The *M. Obturator Internus* Sulcus on Middle and Late Pleistocene Human Ischia

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**ABSTRACT** Recent human ischia and those of Middle and Late Pleistocene hominids exhibit variation in the cranio-caudal location of the sulcus for the internal obturator muscle as it rounds the ischium through the lesser sciatic notch, from being fully cranial of the ischial tuberosity, to bordering the tuberosity, to crossing the superior tuberosity. Among two recent human samples, all three forms exist, with the cranial position of the sulcus being more common in a 20th century Euroamerican sample whereas the intermediate one predominates in a horticultural late prehistoric Amerindian sample. The available Pleistocene *Homo* fossil remains exhibit the full range of variation with no one form being dominant in Middle Pleistocene archaic humans and Middle Paleolithic late archaic and early modern humans. It is only within the Upper Paleolithic that the cranial and intermediate locations for the sulcus become predominant. These patterns therefore indicate that it is inappropriate to use this feature for distinguishing later Pleistocene hominid groups. © 1996 Wiley-Liss, Inc.

In their description of the Middle Paleolithic human remains from Skhul and Tabun, McCown and Keith (1939) drew attention to the configuration and location of the groove for the internal obturator muscle and tendon as it rounds the ischium. They noted that in modern humans the *M. obturator internus* sulcus is normally between the ischial spine and tuberosity, but that in Neandertals and the Skhul and Tabun remains it was frequently across the dorso-cranial tuberosity. More recently, Rak (1990, 1991) documented a large and very prominent sulcus for the internal obturator muscle across the cranial portion of the ischial tuberosity of the Kebara 2 right os coxae. He stated that it was similar to the configurations seen in the Neandertal 1 and Tabun 1 remains, and then employed it as a morphological characteristic to separate the Neandertals from early modern humans.

I was therefore surprised to note, as had

McCown and Keith (1939), that the Skhul 5 ischium presents a morphology similar to that now known for Kebara 2 and that Skhul 4 has a prominent, if more cranially located, groove for *M. obturator internus* on its ischium. In addition, *contra* McCown and Keith (1939) and Rak (1990), the well-preserved Tabun 1 ischium presents the same configuration as the presumed modern human modal pattern. Consequently, it appears appropriate to review the distribution of this morphological complex in Pleistocene hominids, to assess whether it can be used as a Neandertal characteristic.

### THE *M. OBTURATOR INTERNUS* SULCUS

In modern humans, the presumed "normal" (or textbook) configuration is for the

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*M. Obturator internus* to arise from the pelvic surfaces of the superior pubic ramus, the ischio-pubic ramus and the ventral portion of the obturator membrane, with an additional portion originating from the pelvic surface opposite the acetabulum just caudal of the arcuate line (Clemente, 1981; Williams et al., 1989). The muscle converges into several tendinous bands, which curve around the grooved surface of the ischium between the spine and the tuberosity, between the sacrospinous and sacrotuberous ligaments, and hence through the lesser sciatic foramen. From there it converges further into a flattened tendon, which inserts into the medial greater trochanter. As such, its action is primarily that of a hip lateral rotator. When the hip is highly flexed, it also serves as an abductor of the thigh.

As *M. obturator internus* curves around the ischium, it is separated from the bone by a bursa and a layer of cartilage. It is undoubtedly the attachments of this cartilage and bursa which sometimes leave rugose impressions on the ischium.

As noted by McCown and Keith (1939) and Rak (1990), the course of the *M. obturator internus* tendon, and hence the position of its bursa and cartilage, is usually described (e.g., Williams et al., 1989) as being between the ischial tuberosity and spine in modern humans and caudal to the acetabulum. The morphology seen in Kebara 2 and some of the other Middle Paleolithic specimens would therefore represent a more caudal position for the internal obturator tendon and/or a more cranial extension of the superior margin of the ischial tuberosity.

## MATERIALS AND METHODS

### Morphological categories

To evaluate variation in the spatial relationship between the ischial tuberosity and the internal obturator sulcus in both recent humans and Middle and Late Pleistocene humans, specimens were assigned to one of the three categories (Fig. 1). These categories are merely a nominal means of describing what is a continuum between a configuration in which the obturator internus sulcus conforms to the presumed modern hu-

man modal pattern and that which has been described for the Kebara 2 os coxae.

1) the *cranial* position is present when the sulcus is clearly cranial to the ischial tuberosity and separate from it. In this, there is an even concavity between the distinct cranio-dorsal margin of the ischial tuberosity and the ischial spine. This is the presumed "normal" modern human arrangement.

2) The *caudal* position is present when the sulcus for the *M. obturator internus* crosses the cranio-dorsal ischial tuberosity, and it is across the area for the origins of *M. semimembranosus* and the long head of *M. biceps femoris*. In this arrangement, the dorsal margin of the ischial tuberosity exhibits a distinct concavity extending from the cranio-dorsal corner of the tuberosity for some variable distance caudally along the hamstring attachment area. Moreover, given that the cranial extent of the *M. obturator internus* tendon is constrained by the sacrospinous ligament, a caudal position for its sulcus of necessity means that the cranial margin of the ischial tuberosity lies at the same cranio-caudal level as the ischial spine. However, it is possible in this arrangement to have some dorso-ventral separation of the ischial spine and tuberosity, especially given the frequent ventral rotation of the ischial tuberosity in many Pleistocene and recent human ossa coxae.

3) There also exists an *intermediate* configuration, in which the sulcus impinges on the cranio-dorsal corner of the ischial tuberosity but lies in part cranial to the dorso-cranial margin of the tuberosity. In this configuration, the sulcus clearly abuts against the ischial tuberosity and impinges upon the area of origin for *M. semitendinosus* and *M. biceps femoris*.

In addition, there is sometimes a prominent swelling of bone extending from the cranio-dorsal corner of the ischial tuberosity toward the ischial spine, giving the impression of a cranio-dorsal extension of the tuberosity. However, this swelling lacks the distinct rugosity associated with the origins of the hamstring muscles and usually exhibits fine grooves which run between the tuberosity and the ischial spine. When present, this swelling provides the surface for the *M. obturator internus* sulcus and may be related



Fig. 1. Dorso-lateral views of right ischia (perpendicular to the dorso-lateral plane adjacent to the acetabulum) exhibiting, from left to right, the cranial, the intermediate and the caudal positions of the *M. obturator internus* sulcus relative to the ischial tuberosity. The intermediate and caudal position specimens also exhibit a swelling between the tuberosity and the spine, as well

as small osteophytes along the lateral sulcus margin. All three specimens are 20th century Euroamerican females from the documented collection of the Maxwell Museum, University of New Mexico; the specimen on the left experienced a fracture of the pubic ramus displacing the position of the pubic symphysis but not affecting the ischium.

to the attachment of the bursa for the *M. obturator internus* tendon. This swelling also usually exhibits a concavity along its dorsal margin for the *M. obturator internus* tendon. Whatever the actual attachments along this swelling, it is clearly not part of the ischial tuberosity since it exhibits none of the characteristic rugosity for the origins of the hamstring muscles.

This configuration has also been categorized as intermediate, since it represents a morphology between the full overlap and the full separation of the obturator internus sulcus and the ischial tuberosity. This arrangement, which is seen in several Pleistocene archaic *Homo* specimens [e.g., La Chapelle-aux-Saints 1, Krapina 207, Neandertal 1 (Table 1)] as well as many recent humans, should not be confused with the caudal position.

In scoring specimens, care has to be taken to distinguish the relative positions of the sulcus and tuberosity from two associated

features. In many Pleistocene and recent human specimens there is a ventral rotation of the ischial tuberosity relative to the dorso-lateral plane of the ischium adjacent to the acetabulum. This tends to accentuate the dorso-ventral separation of the ischial tuberosity and spine and to make the sulcus appear enlarged and more caudally located. In addition, there is occasionally an apparent deepening of the sulcus as a result of the formation of osteophytes or osteophytic ridges along its cranial and caudal margins. This is evident on the Kebara 2 and Skhul 4 ischia and frequently in recent humans. Both of these aspects introduce variation separate from the relative position of the *M. obturator internus* sulcus and should not be considered in the characterization of the morphology of concern here.

### Samples

To provide a baseline for the assessment of the fossil specimens and to assess the de-

TABLE 1. M. obturator internus sulcus position relative to the ischial tuberosity for samples of Middle and Late Pleistocene members of the genus *Homo*

Specimen	Sex	Side	Morphology	Source
Middle Pleistocene				
Arago 44	M	left	(caudal)	cast
Broken Hill E719	M	right	intermediate	original
OH 28	F	left	cranial	cast
Near East late archaic				
Kebara 2	M	right	caudal	original; Rak, 1990
Tabun 1	F	right	cranial	original
Europe late archaic				
La Chapelle-aux-Saints 1	M	left	intermediate	original; photo
Krapina 207	M	left	intermediate	cast; original
Krapina 208	F	right	cranial	original; photo
Krapina 255.9	??	left	cranial	original; photo
Neandertal 1	M	left	intermediate	original; photo
Régourdou 1	??	right	cranial	cast
Near East early modern				
Qafzeh 9	F	right	(cranial)	Rak, 1990
Skhul 4	M	right	intermediate	original
Skhul 5	M	right	caudal	original
Europe early modern				
Cro-Magnon 4315/4318	M	right and left	cranial	original; photo
Mladeč 21	F	left	intermediate	original; photo
Mladeč 22	??	right	cranial	original; photo
Pataud 26235	F	right	intermediate	original; photo
Paviland 1	M	left	cranial	original
Předmostí 3	M	right	cranial	Matiegka, 1938
Předmostí 4	F	left	intermediate	Matiegka, 1938
Předmostí 9	M	left	intermediate	Matiegka, 1938
Předmostí 14	M	right	cranial	Matiegka, 1938
East Asian early modern				
Minatogawa 1	M	right and left	cranial	Baba and Endo, 1982
Minatogawa 2	F	right	cranial	Baba and Endo, 1982
Minatogawa 3	F	right	cranial	Baba and Endo, 1982

See text for definitions of the morphological categories.

gree of variation present in recent human samples of adequate size, ischia from two contrasting modern human samples were scored. The first consists of 50 males and 50 females of 20th century Euroamericans of known sex from the documented collections of the Maxwell Museum, University of New Mexico. The second sample consisted of 56 males, 49 females and 4 individuals of indeterminate sex from the late prehistoric Rio Grande Puebloan Amerindian sites of Pottery Mound and Kuaua, New Mexico. The former sample consists of relatively inactive modern industrial society individuals, whereas the latter includes physically active individuals from a horticultural and foraging village-based society. All individuals were at least late adolescent in age, with the ischial tuberosity epiphysis at least partially fused and therefore unlikely to experience significant morphological change from additional growth. Sex was documented for the

Euroamerican sample and pelvically assessed for the Amerindian one.

The available Pleistocene genus *Homo* fossils were divided into six samples: a geographically heterogeneous Middle Pleistocene one (including African and European remains), Near Eastern and European late archaic (Neandertal *sensu lato*) humans, New Eastern Middle Paleolithic early modern humans (from the sites of Qafzeh and Skhul), and European and east Asian Upper Paleolithic early modern humans (Table 1). All specimens were assigned to one of the morphological categories based on examination of the original specimen, high quality casts and/or high quality and detailed photographs of the original specimen (see "source" in Table 1).

In most cases, damaged or uncertain specimens were not included. Three exceptions to this are Arago 44, Kebara 2 and Qafzeh 9. The first has damage to the dorso-cranial

ischial tuberosity, but retains both the *M. semimembranosus* origin area and most of the *M. obturator internus* sulcus, making the position of the sulcus clear. The second entirely lacks the ischial spine (Rak, 1991). However, a sufficient portion of the adjacent bone is preserved to indicate the overall position of its obturator internus sulcus, even though the cranio-caudal relationship between the spine and the cranial tuberosity margin cannot be confirmed. The last experienced extensive damage to the ischial tuberosity area (Vandermeersch, 1981), and the attribution here to the "cranial" morphology is based on the assessment of Rak (1990). Given the claim by Rak (1990) that the morphology of this region separates Near Eastern Middle Paleolithic late archaic humans from early modern human ones, inclusion of this attribution, if anything, biases the result in the direction of his proposition.

Most of the fossil samples (Tables 1 and 3) are too small to provide meaningful distributions or *P* values. The Pleistocene specimens were therefore compared first in terms of the simple presence/absence of the morphological categories. The Late Pleistocene remains were then grouped into Eurasian late archaic and early modern human samples, raising the respective sample sizes to a still modest 8 and 15.

### Sample comparisons

To compare the frequency distributions between pairs of samples or subsets of them to assess whether there are significant differences between them in these categories of the internal obturator sulcus position, Fisher's exact test (with an  $H_0$  of similarity) was employed. The multiple comparisons were preceded with a Kruskal-Wallis test across the four samples (two recent and two Late Pleistocene), which produced a global  $P < 0.0001$ . Nonetheless, a Bonferroni multiple comparison correction for the six pairwise comparisons was employed, such that a  $P < 0.008$  would be necessary for an  $\alpha$  level of 0.05 and a  $P < 0.002$  for an  $\alpha$  level of 0.01.

All of the comparisons are based on the raw counts by individual. The *P* values were calculated as exact probabilities using StatXact-Turbo 2.1 (Mehta and Patel, 1992). StatXact calculates the probabilities using

exact permutational algorithms based on the raw counts for the samples; the *P* values are therefore accurate "no matter how sparse, skewed, or heavily tied the data are" (Mehta and Patel, 1992:1-5).

Only two of the fossil specimens (Cro-Magnon 4315/4318 and Minatogawa 1) preserve right and left ischia sufficiently intact for scoring, and they are both symmetrical with respect to these categories. In the recent Euroamerican sample, only 4% ( $N = 100$ ) exhibit asymmetry and in each case the asymmetry involved adjacent configurations (three cranial/intermediate and one intermediate/caudal). One case of asymmetry was observed in the Amerindian sample, which produced a  $P = 0.812$  (right  $N = 88$ , left  $N = 69$ ). Consequently, the bilaterally intact and symmetrical individuals were scored as 1.0 for the morphological category evident, and the few asymmetrical individuals had each side counted as 0.5. For the remaining Pleistocene and Amerindian individuals who retain only one intact ischium, symmetry was assumed and the category indicated by the preserved side was used to represent the individual.

In addition, despite attempts to accurately assign specimens to one of the above three morphological categories, there are specimens which (not surprisingly given the continuous nature of the variation involved) fall between these three categories. There are six such individuals in the Amerindian sample and eight in the Euroamerican sample. In the tabulations, they were scored as 0.5 in each category.

In both of the recent human samples (Table 2), the males and females exhibit similar levels of the caudal position, but the females in each sample have slightly higher percentages of the cranial position and consequently lower percentages of the intermediate pattern. However, the differences are not significantly different, since  $P = 0.689$  and  $0.674$  respectively for the Amerindian and Euroamerican samples. In the Pleistocene *Homo* sample (Table 1), there is a similar trend in which the females lack the caudal position and have a higher frequency of the cranial position, but the pooled male and female distributions remain insignificantly different, with  $P = 0.255$ . Given these male-

TABLE 2. Frequency distributions of the position of the *M. obturator internus sulcus* in samples of recent humans

	Cranial position	Intermediate position	Caudal position	N
Puebloan				
Amerindians				
Total sample	17.0%	69.3%	13.8%	109
Males	14.3%	72.3%	13.4%	56
Females	19.4%	66.3%	14.3%	49
Modern				
Euroamericans				
Total sample	69.0%	29.0%	2.0%	100
Males	67.0%	32.0%	1.0%	50
Females	71.0%	26.0%	3.0%	50

See text and Figure 1 for descriptions of the categories.

female similarities and the same (for the Euroamericans) and similar (for the Amerindian and Pleistocene *Homo*) sample sizes by sex, the sexes were pooled in the statistical comparisons; possible implications of these trends are, however, discussed below.

## RESULTS

### Recent human samples

The two recent human samples exhibit contrasting distributions of the cranio-caudal position of the *M. obturator internus* sulcus, with the majority of the Euroamerican sample exhibiting the fully cranial position and an almost equal proportion of the Amerindians having the intermediate position. Moreover, the fully caudal position is rare in the Euroamerican sample, with only one individual exhibiting a fully caudal sulcus and three individuals having the sulcus between the intermediate and caudal positions. In the Amerindian sample, however, 14 (12.8%) have at least one ischium with the fully caudal position of the sulcus, with two more individuals exhibiting a slightly more cranial position for the sulcus. As a result of this, the two sample distributions are highly significantly different (Table 4).

Consequently, even though the presumed "normal" position for the sulcus in modern humans, the cranial one, is the most frequent in the Euroamerican sample, the intermediate position is still present in about 30% of that sample and occurs in almost 70% of the Amerindian sample (Table 2). Moreover, even though the caudal position is less common in the recent humans samples and rarely is the sulcus markedly caudal on the

ischial tuberosity, it is by no means exceptional in those samples.

### Pleistocene *Homo*

The Pleistocene *Homo* ischia exhibit considerable variation in the position of the *M. obturator internus* sulcus relative to the ischial tuberosity (Figures 2, 3; Table 1). The small Middle Pleistocene sample is only sufficient to document that all three patterns existed among the precursors to Late Pleistocene and Holocene humans. The Near Eastern Middle Paleolithic samples exhibit the same range, and given limitations of sample size, essentially the same distributions. The European late archaic and early modern humans have similar frequencies of cranial and intermediate positions and both lack the caudal position. Only the small late Upper Paleolithic east Asian sample from Minatogawa contrasts with the other Pleistocene samples in having only one extreme position of the internal obturator sulcus.

The pooled early modern human distribution falls between those of the two recent human samples, being close to the Euroamerican sample in having the majority of the specimens with the cranial position of the sulcus and a rarity of the caudal position (Table 3). The pooled late archaic humans also fall between the two recent human samples in this feature, but are about equidistant from each. There is no significant difference between the two Late Pleistocene samples, with  $P = 0.700$ , and only the early modern human sample is significantly different from one of the recent human samples (with or without the Bonferroni multiple comparison correction) (Table 4).

More importantly, even though sample sizes are insufficient to compute meaningful statistics, it is apparent that it is not possible to use the position of the obturator internus sulcus to distinguish between the Near Eastern Middle Paleolithic Qafzeh-Skhul sample and either the Near Eastern or European late archaic human samples. Indeed, there are only three fossil specimens which exhibit a clear caudal position of the *M. obturator internus* sulcus, and they are a European Middle Pleistocene archaic human (Arago 44), a Near Eastern Middle Paleolithic late archaic human (Kebara 2), and a Near East-

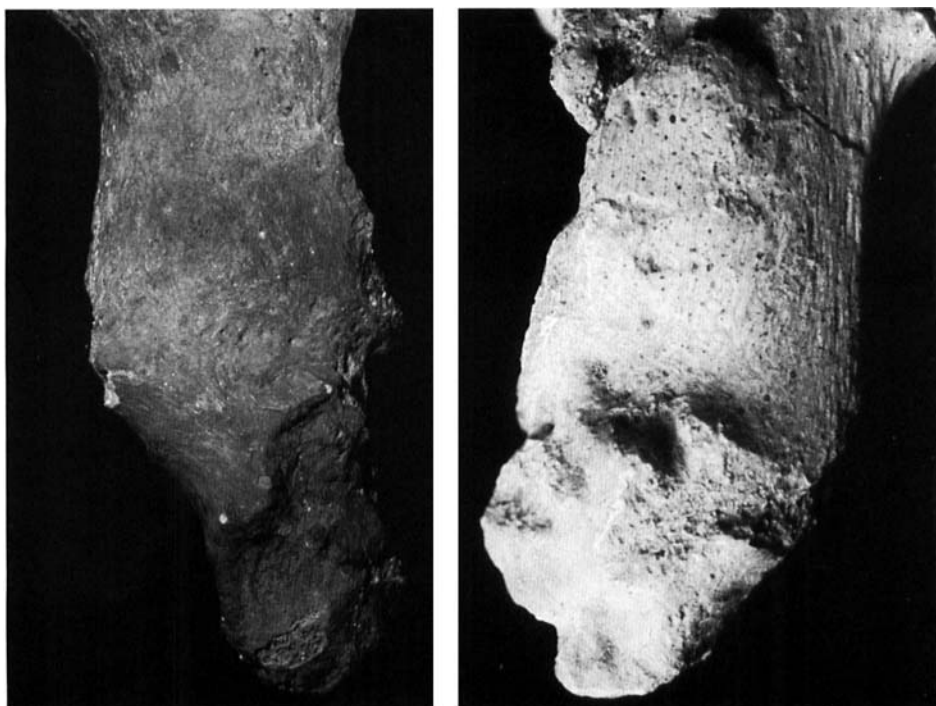


Fig. 2. *M. Obturator internus* sulci on Middle Pleistocene human ischia. **Left:** Broken Hill (Kabwe) E719 right ischium, with the sulcus in the intermediate position, impinging on the cranio-dorsal tuberosity. **Right:** Arago 44 left ischium (cast), with the remains of the internal obturator sulcus rounding onto the ischial tuberosity, hence in the caudal position.

ern Middle Paleolithic early modern human (Skhul 5). Given the presence of unambiguous caudal positions for the sulcus on these three specimens (one Middle Pleistocene non-Neandertal archaic human, one Neandertal and one early modern human), it should be apparent that this configuration cannot be used as a unique Neandertal trait, regardless of its frequency in recent human samples.

If anything, the fossil data appear to provide a contrast primarily between the Middle and Upper Paleolithic samples (independent of archaic vs. early modern human overall morphology) (Table 3), even though the samples remain insignificantly different ( $P = 0.314$ ).

It should be noted that there are five fossils specimens which are scored differently from the characterizations provided by McCown and Keith (1939) and/or Rak

(1990): La Chapelle-aux-Saints 1, Krapina 207 and 208, Neandertal 1 and Tabun 1. The differences of interpretation regarding La Chapelle-aux-Saints 1, Krapina 207 and Neandertal 1 are undoubtedly the product of the presence of prominent swellings extending from the ischial tuberosity to the spine around which the sulcus is formed, especially on Krapina 207 and Neandertal 1. The swellings, however, must be considered to be cranio-dorsal of the tuberosity and not part of the tuberosity proper, since there are clear cranio-dorsal margins of the hamstring muscular attachment areas caudal and ventral of the swellings, and they exhibit the nonmuscular longitudinal striations referred to on page 504. Given this, these specimens should be classified as intermediate and are so treated here. Only if the swelling is (incorrectly) considered to be part of the tuberosity could they then be viewed as cau-

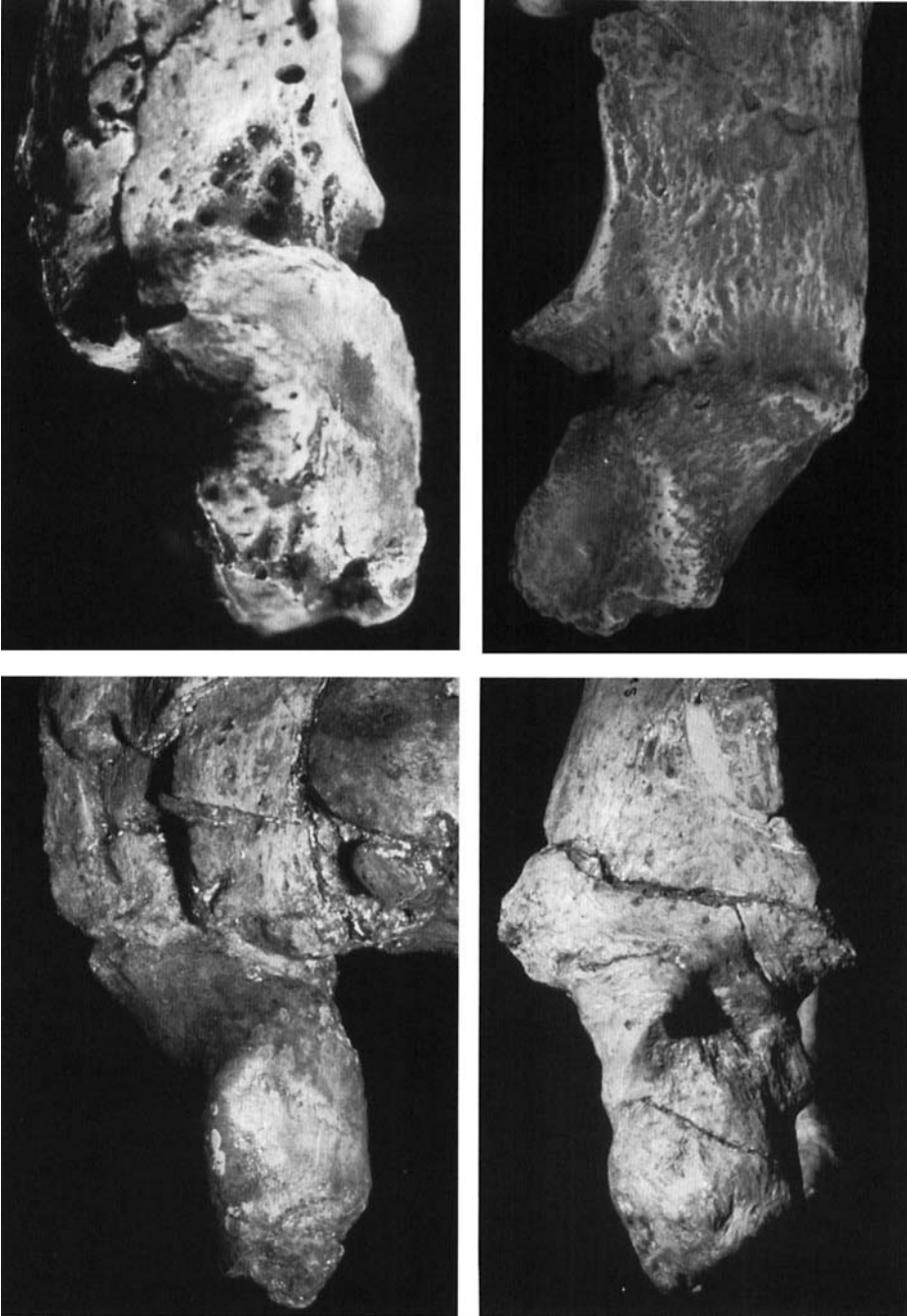


Fig. 3. *M. obturator internus* sulci on Late Pleistocene Middle Paleolithic human ischia. **Upper left:** Kebabara 2 right ischium (cast) with a large sulcus in the caudal position. **Upper right:** Krapina 207 left ischium (cast) with a broad sulcus in the intermediate position, including a swelling of bone from the dorso-cranial is-

chial tuberosity to the ischial spine. **Lower left:** Tabun 1 right ischium with a sulcus in the cranial position, distinct from the ischial tuberosity (the femoral head is fused into the partially crushed acetabulum). **Lower right:** Skhul 4 right ischium with a prominent sulcus in the intermediate position.



TABLE 3. Frequencies of the position of the *M. obturator internus sulcus* in Middle and Late Pleistocene human samples by region and summed for Eurasian late archaic and early modern humans

	Cranial position	Intermediate position	Caudal position	N
Middle Pleistocene	33.3%	33.3%	33.3%	3
Near East late archaic	50.0%	0.0%	50.0%	2
Europe late archaic	50.0%	50.0%	0.0%	6
Near East early modern	33.3%	33.3%	33.3%	3
Europe early modern	55.6%	44.4%	0.0%	9
East Asia early modern	100%	0.0%	0.0%	3
Eurasian late archaic	50.0%	37.5%	12.5%	8
Eurasian early modern	60.0%	33.3%	6.7%	15

TABLE 4. Fisher exact test *P* values for pair-wise sample comparisons of internal obturator sulcus positions, based on the raw counts

	Amerindian	Early Modern	Late Archaic
Euroamerican	<0.0001**	0.377	0.096
Amerindian		0.004*	0.160
Early Modern			0.700

\* $P < 0.05$  and \*\* $P < 0.01$ , each with a Bonferroni correction.

dal.<sup>1</sup> In addition, McCown and Keith (1939) characterized Krapina 208 and Tabun 1 as intermediate and Rak (1990) described Tabun 1 as having the caudal position. However, in neither specimen is there an impingement of the sulcus on the ischial tuberosity or the presence of a swelling extending cranio-dorsally from the tuberosity, making it impossible to correctly view them as either intermediate or caudal.

Nonetheless, to determine the effects of these differences of interpretation, the statistical comparison of the Eurasian late archaic to early modern humans was redone using McCown and Keith's (1939) interpretations of these five specimens. Whereas the morphological assessments provided here furnish no meaningful statistical difference between the two pooled late Pleistocene samples, using McCown and Keith's characterizations does increase the difference, providing a  $P = 0.069$ . However, even without a Bonferroni correction for the multiple com-

parisons, this difference does not reach significance at the  $P < 0.05$  level.

## DISCUSSION AND CONCLUSION

These data therefore indicate, as noted by McCown and Keith (1939), that there is considerable variation in this morphological region within Middle Paleolithic Near Eastern and European hominid samples. Both of these samples have ischial configurations similar to those of the available European and African Middle Pleistocene specimens, but contrast only moderately with more recent samples of humans. Indeed, the greatest contrast is between preindustrial and postindustrial recent humans, with the fossil samples falling between those two extremes. Consequently it is not reasonable to use this feature to distinguish Near Eastern or European late archaic humans from Eurasian early modern humans, especially from the Middle Paleolithic Qafzeh-Skhul remains. Moreover, the consistent presence of within-sample variation in this anatomical region means that no one configuration can be validly employed as a taxonomic or phylogenetic marker for one of these later Pleistocene hominid groups.

It is nonetheless interesting that this similar range of variation in ischial tuberosity and *M. obturator internus* sulcus morphology occurs in the context of contrasts in hominid pelvic proportions between early Middle and Late Pleistocene archaic *Homo* involving the shift from a more platypelloid pelvis to a rounder one (Ruff, 1995), and between late archaic and early modern Middle Paleolithic humans involving reduction in the relative medio-lateral dimension of the pubic region (Trinkaus, 1976, Heim, 1982, Rak and

<sup>1</sup>The only other late archaic human specimen which could be included in this sample is La Ferrassie 1. It does exhibit a prominent swelling between the ischial spine and the ischial tuberosity, but damage to most of the ischial tuberosity and its restoration in plaster (Heim, 1982) means that it is unclear whether it should be categorized as cranial or intermediate.

Arensburg, 1987; Rak, 1990). Moreover, despite general similarity in pelvic structure (Tague, 1989), the two recent human samples have markedly different distributions in the position of this sulcus.

There is a suggestion in the moderate but nonsignificant sexual differences, in which females have a higher frequency of the cranial position, and in the marked difference between the recent Amerindian and Euroamerican samples that locomotor robusticity may be influencing this cranio-caudal position of the internal obturator sulcus relative to the ischial tuberosity. This would follow the pattern of robusticity in femoral diaphyses between Puebloan Amerindians and modern Euroamericans (Ruff et al., 1993). However, sexual dimorphism in femoral diaphyseal robusticity in these samples is small and variable (Ruff, n.d., unpub. data). Moreover, the position of Late Pleistocene *Homo* between the recent Amerindian and Euroamerican samples in internal obturator sulcus position frequencies does not follow the relative levels of locomotor robusticity of these samples, in which Late Pleistocene femora (both archaic and early modern) are the most robust and Euroamerican femora are the most gracile (Ruff et al., 1993).

Consequently, the functional significance of this variation is unclear, but it is undoubtedly related to a combination of ischial length, the cranio-caudal position of the ischial spine (and hence the sacrospinous ligament), the cranio-caudal position of the superior margin of the ischial tuberosity, the habitual degree of ventral pelvic tilt [similar at least in the Neandertals and early modern humans, based on lumbar vertebral body wedging (Trinkaus, 1983; Arensburg, 1991)], the cranio-caudal position of the greater trochanter relative to the acetabulum, which is related to the length of the femoral head and neck and the neck-shaft angle, and perhaps the external breadth of the pelvic outlet relative to biacetabular breadth.

Variation in the position of the sulcus for the internal obturator muscle therefore poses interesting functional questions resolvable only in the context of complete hip anatomy. It does not, however, provide a character for distinguishing late archaic

from early modern Middle Paleolithic hominids.

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